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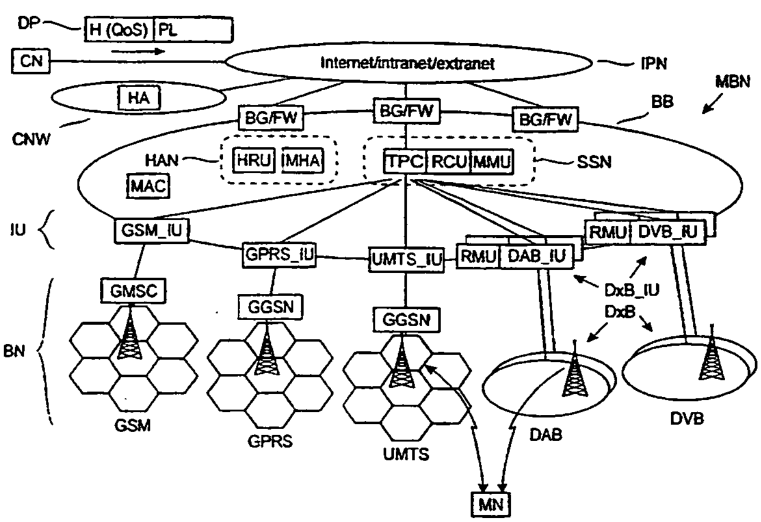
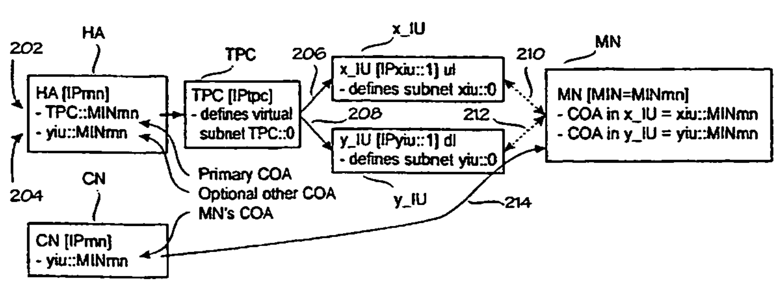
(54) Title: ARCHITECTURE AND PACKET ROUTING IN A MULTI-BEARER-TYPE NETWORK





(57) Abstract: A method for routing data packets (DP) to a mobile node (MN) from its correspondent node (CN), via a multi-bearer network, or MBN. The MBN comprises uplink bearer networks (GSM, GPRS, UMTS) and downlink bearer networks (DxB). The method comprises: 1) storing an address (202) associated with a centralized traffic policy controller (TPC) as the mobile node's care-of address in its home agent (HA); 2) routing an initial data packet via the home agent and the centralized traffic policy controller to a bearer network interface unit (DxB_IU, DL_IU) serving the mobile node; 3) storing an address (214) of the bearer network interface unit as the mobile node's care-of address in the correspondent node (CN); 4) routing subsequent data packets from the correspondent node (CN) to the bearer network interface unit (DxB_IU, DL_IU), whereby the home agent (HA) and the centralized traffic policy controller are bypassed.

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Architecture and packet routing in a multi-bearer-type network

Background of the invention

The invention relates to traffic management in a multi-bearer packet data network. A multi-bearer network, or an MBN, is a network having the capability to carry a data packet via one of several alternative bearers. To be more precise, the term "multi-bearer network" should be interpreted as meaning "multi-bearer-type network", or in other words, a network arrangement which provides multiple different bearer types for data packet delivery. An example of an MBN is a concept known as MEMO (Multimedia Environment for Mobiles), see reference 1. Additionally, the MBN supports mobility of a subscriber terminal. An example of terminal mobility is IP (Internet Protocol) mobility, which is the topic of standard RFC2002 and an Internet Draft *"Mobility Support in IPv6"*, by C. Perkins and D. Johnson, dated 28 October 1999 by the Internet Engineering Task Force (IETF). The network layer protocol to be used in the invention, IPv6, is described in documents RFC-2460: *"Internet Protocol, Version 6 (IPv6) Specification"* and RFC-2373: *"IP Version 6 Addressing Architecture"*. These RFC standards are incorporated herein by reference. The status of these Internet drafts is "work in progress".

A generic problem underlying the invention is that the MEMO concept is very limited. It only contemplates one uplink bearer type, namely GSM (Global System for Mobile Communication), and one downlink bearer type, namely DAB (Digital Audio Broadcast). Within the context of this application, 'uplink' means from the mobile node MN to the correspondent node CN and 'downlink' means the inverse direction.

Expanding the MEMO concept to multiple alternative uplink and/or downlink bearer types causes more specific problems. One of the specific problems is how to select an optimal bearer for each data packet in varying situations in an MBN. Data packets have different quality-of-service requirements. Situations may vary because the subscriber moves or the network load changes. Another specific problem is how to route the traffic to the mobile node via the selected bearer and to design suitable network elements and MBN architecture.

Disclosure of the invention

The object of the invention is to provide methods and equipment for solving the specific problem related to bearer selection in an MBN.

This object is achieved with a method and equipment which are characterized by what is disclosed in the attached independent claims. Preferred embodiments of the invention are disclosed in the attached dependent claims.

The invention is based on a novel distribution of functions within an MBN. The functions are distributed over four major nodes or node sets. In addition, the MBN comprises a physical or virtual backbone network (BB). A first node set, called access control nodes, grants or rejects user rights within the MBN. This set also stores subscriber preference information.

A second node set, called home administration nodes (HAN), comprises a home registration unit (HRU) for storing subscriber registration and preference information, such as access right information. For instance, a subscriber may be a national subscriber and not pay for any roaming support. Another user may elect roaming support in major European cities. The available options depend entirely on the service providers. The HAN node set also comprises an MBN home agent (MHA), which is a special version of a home agent. It supports a mobile node that uses an MBN-specified IP address as its home addresses. Each MN subscriber which is registered for MBN service has an entry in the HRU of the home network. An MBN serves its subscribers regardless of which IP address is used as the mobile node's home address for communicating with the correspondent node.

A key concept in the mobile-IP protocol is the home agent (HA). For each mobile node, there is one home agent. The home agent is a routing entity in a mobile node's home network which tunnels packets for delivery to the mobile node when it is away from its home network, and maintains current location information for the mobile node. The home agent per se is known to the skilled reader. But the invention is also partially based on the idea that the home agent function is supplemented with a home register unit (HRU) which is a separate entity from the home agent. Separating the home register unit from the home agent allows more freedom in positioning the home agent. In other words, the home agent can be located virtually in any network, and the mobile node can use its own IP address instead of the one provided by the MBN. Thus a mobile node is allowed to use either an IP address provided by the MBN or an IP address provided by some other network. If the mobile node uses an MBN-provided IP address as its home address for communicating with its correspondent node, the MHA acts as the mobile node's home agent.

If the MN uses an IP address provided by eg a corporate network, the home agent in that network is the mobile node's home agent.

A third node set, called service support nodes (SSN), is in charge of centralized traffic policy control, mobility management and resource reservation decisions. The SSN node set also controls starts of sessions and routes the first packet(s) of new sessions. Normally the SSN node set does not route subsequent packets of ongoing sessions. Instead, the mobile node updates its mobility binding with its correspondent node, after which the traffic bypasses the SSN nodes. For some reason, a mobile node may not want to send a mobility binding update message. In this case, the SSN nodes route all traffic to the mobile node.

The service support nodes (SSN) comprise a traffic policy controller (TPC) within the backbone network. Later in this application, the traffic policy controller is frequently shortened to "traffic controller". The traffic (policy) controller makes centralized routing policy decisions but does not route all packets itself. It only routes the first packet or the first few packets of a new session and helps other network elements to communicate directly with each other. The SSN nodes also comprise a resource coordination unit (RCU) from which the TPC checks resource availability before making decisions about traffic allocation. The traffic controller also requests the resource coordination unit to reserve resources for a flow when necessary (for guaranteed service). Moreover, the traffic controller selects a downlink bearer on the basis of traffic flow or/and traffic class. The SSN node set also comprises a mobility management unit (MMU) which supports the mobile node in handovers within a TPC area and between two TPC areas.

The TPC, RCU and MMU are preferably closely coupled or within the same network element. This means that the mobile node is not burdened with addressing these functions separately. Instead, these functions share a common IP address, and the MN communicates with the TPC which distributes MN-originated information with the RCU and the MMU.

Each traffic policy controller (TPC) has an area of responsibility. Such an area will be called a TPC area. The TPC area comprises the cells broadcasting the TPC's IP address or other unique TPC identifier. Because the cell size varies and the cells are partially overlapping, the TPC area has no clearly-defined geographical border, and a mobile node may be located geographically in two or more neighbouring TPC areas simultaneously. However,

the mobile node can be registered with (ie reachable via) one TPC at any time. In such a situation, the mobile node selects the TPC controlling the cell with the best signal quality. Moreover, the area of a certain TPC is likely to be different between the various bearer networks. In other words, the TPC area for DVB is different from the TPC area for DAB.

A fourth node set, called interface units (IU), acts as interfaces to the various bearer networks. The primary function of the interface units is to encapsulate IP packets into protocols suitable for the bearer network in question, and to control incoming traffic to a bearer network or a broadcast cell. The interface unit of a broadcast cell also monitors and controls the resource usage and reports resource availability to the SSN nodes.

Each interface unit (IU) toward the broadcast bearer networks comprises or is closely coupled to a resource management unit (RMU). The RMU controls the physical resource allocation in each cell under it. It also acts as a peer entity of the resource coordination unit to respond to resource allocation requests. More specifically, the RCU makes decisions concerning resource allocation but the RMU maps each data flow to one or more physical or logical channels of the specific broadcast station.

The bearers include a first set of bidirectional bearers. Examples of bidirectional bearers are circuit-switched mobile networks, such as GSM (Global System for Mobile communications), and packet-switched mobile networks, such as GPRS (General Packet Radio Service), and third generation mobile networks, such as UMTS (Universal Mobile Telecommunications System), which offer both circuit-switched and packet-switched bearers. The bearers also include a second set of unidirectional bearers. Examples of unidirectional bearers are digital audio broadcast (DAB) and digital video broadcast (DVB). The set of unidirectional bearers can also be called broadcast bearers, and the set of bidirectional bearers can also be called non-broadcast bearers.

A multi-bearer network according to the invention comprises a backbone network which is preferably based on IPv6 (Internet Protocol version 6) with mobility support. The backbone network has border gateway nodes towards the Internet and interface units (IU) towards the various bearer networks.

The invention provides mobility support in an MBN in an elegant manner. There is a first set of centralized access control nodes, a second set of centralized traffic (policy) control nodes and a third set of interface nodes for

each bearer network. The mobile node and its correspondent node are not burdened with addressing each node or functionality separately. To access services within the MBN, the mobile node is only required to have some rights in one bidirectional (uplink) bearer network.

Brief description of the drawings

The invention will be described in more detail by means of preferred embodiments with reference to the appended drawing wherein:

Figure 1 is a block diagram illustrating an overall network architecture;

Figure 2 illustrates addressing within the MBN;

Figure 3 shows a traffic handling policy table THPT;

Figure 4 shows a mapping table QMTC for mapping QoS (Quality of Service) in a packet's IP header into a traffic class within the MBN;

Figure 5 shows a list ACAL of the mobile node's available care-of address;

Figure 6 is a signalling diagram illustrating registration and resource reservation;

Figure 7 is a signalling diagram illustrating the start of a session;

Figure 8 illustrates a microcell architecture for DxB networks; and

Figure 9 illustrates the various data structures used in the system shown in Figure 8.

Detailed description of the invention

Figure 1 is a block diagram illustrating an overall network architecture. Reference sign MN denotes the mobile node. Reference sign CN denotes the mobile node's correspondent node, which is a host or server the mobile node is communicating with. The mobile node MN communicates with its correspondent node CN via a multi-bearer network MBN which offers several alternative bearers for a data packet DP. The MBN comprises a physical or virtual backbone network (BB). The mobile node MN is able to communicate with several bearer networks BN. The bearer networks comprise at least one bidirectional bearer network (in this example: GSM, GPRS or UMTS) and at least one unidirectional or broadcast bearer network (in this example: DAB and DVB). The DAB and DVB are commonly referred to as DxB. The DxB networks are the principal bearers for downlink traffic. The mobile node uses the bidirectional (uplink) bearers primarily for accessing the services of the

MBN, although some bidirectional bearers, most notably the UMTS, can be used for downlink traffic with a moderately high speed. For clarity, the bearer networks are shown as distinct in Figure 1, but in reality they are geographically overlapping, and a mobile node may have access to all bearer networks at the same time. The bearer networks BN per se are known to the skilled reader, and especially the bidirectional bearer networks can be largely treated as black boxes.

Each data packet DP comprises a header H and a payload part PL. To be precise, a data packet typically has several headers inside each other, because each protocol layer inserts its own header. However, each protocol layer only handles its own header, and a model with only one network layer header is usually sufficient for describing the invention. The header indicates, directly or indirectly, a quality-of-service requirement QoS for the data packet. An example of a direct QoS indication is a case where a data packet header includes a parameter which is or which can be directly mapped to a quality-of-service requirement parameter. An example of an indirect QoS indication is a case where a (Transmission Control Protocol) data packet header indicates a port number which in turn indicates the QoS requirement. It should be understood that 'quality of service' is a very generic term indicating certain requested or negotiated transmission characteristics, such as bit rate, maximum delay and/or packet loss probability. Depending on the actual protocol used, quality of service is indicated by or mapped to one (or more) of the existing appropriate fields, such as the Traffic Class field of IPv6. The term 'traffic class' is used to refer collectively to the fields which are used to indicate the quality-of-service requirement.

In the arrangement shown in Figure 1, the MBN communicates with the CN via an IP Network IPN, such as the Internet or an intranet/extranet. A border gateway node BG interfaces the MBN to the IP network IPN. The border gateway BG is typically a simple (but sufficiently powerful) router which preferably includes a firewall function FW. A backbone network BB combines the different bearer networks BN. The backbone network may be the MBN operator's internal network. A physical example of a backbone network is a high-speed local-area network or a wide-area network. The backbone network BB is based on IPv6 (Internet Protocol version 6) or a later version, with mobility support.

In a system as shown in Figure 1, the access control node set is implemented as an MBN authentication centre MAC, which provides centralized grant or denial of the mobile node's rights to services via the backbone network BB. The MAC also stores subscriber preference information related to the mobile node.

A second node or node set, called HAN (home administration nodes), supplements the mobile IP home agent function. The HAN nodes comprise a home registration unit (HRU) for storing subscriber registration and preference information, such as access right information. The HAN nodes also comprise an MBN home agent (MHA), which is a special version of the home agent. Separating the home register unit from the home agent allows more freedom in positioning the home agent. The home agent can be located virtually in any network, and the mobile node can use its own IP address instead of the one provided by the MBN. Accordingly, in the example shown in Figure 1 the home agent HA of the mobile node MN is in the MN's corporate network CNW.

The home agent HA is a key concept in the mobile-IP protocol. For each mobile node, there is one home agent. The home agent is a routing entity in a mobile node's home network which tunnels packets for delivery to the mobile node when it is away from its home network, and maintains current location information for the mobile node. It tunnels datagrams for delivery to, and detunnels datagrams from, a mobile node when the mobile node is away from its home network.

The home register unit HRU stores the user registration information, such as an Access Permission List (APL, see Figure 6) which indicates the MN's rights in each BN. The HRU also stores the subscriber's preference information, which indicates what quality of service the subscriber requires from various applications (or for specific incoming traffic classes). An example of such preference information is the QMTC table shown in Figure 4. The HRU of a visiting MN may be located in a different MBN. In such a case, the HRU of the visited MBN may consult the HRU of the MN's home MBN. If the traffic handling policy of the MN's home network differs from the policy of the visited network, the HRU should adapt the preference information accordingly, such that the user receives the expected quality of service.

A third node set, called SSN (service support nodes), provides centralized administration and distribution of traffic policies (see Figures 3 and 4).

The SSN node set combines the MN-specific subscriber preference information and operator-specific policy information into an MN-specific traffic handling policy which the SSN node set used to make decisions concerning cell and/or channel selection. The MN-specific traffic handling policy is also distributed to the interface nodes which route the packets of ongoing sessions. It may route the first data packet(s) of new sessions but does not route subsequent data packets of ongoing sessions if the MN sends its updated mobility binding information to the CN. The traffic control node set also supports centralized mobility management for managing the mobility of the mobile node within the downlink bearer networks DxB, and it makes centralized resource reservation decisions within the downlink bearer networks. In the arrangement shown in Figure 1, the SSN node set comprises a traffic (policy) controller TPC. Each traffic controller comprises or is closely coupled to a resource coordination unit RCU and a mobility management unit MMU.

A fourth node set, called interface units IU, acts as interfaces to the bearer networks BN. The IU nodes also carry out the resource reservation decisions in the downlink bearer networks DxB. In Figure 1, the interface units are labelled xx_IU, where 'xx' is the relevant bearer network. More precisely, the backbone network BB preferably has one (or more) interface unit towards each bearer network having inherent mobility support (GSM, GPRS and UMTS) and one interface unit towards each cell in a bearer network not having inherent mobility support (DxB). Each DxB interface unit comprises or is closely coupled to a resource management unit (RMU).

The mobile node MN must be able to communicate with several bearer networks BN. It implements IPv6 with mobility support. It monitors selected links (physical channels of DxB) for router advertisement messages. Thus it gains knowledge of the various routers within the MBN. The MN has a unique MIN number (MBN interface number) for automatic care-of address configuration. The MN is able to send an authentication message for registering with the backbone network BB via an interface unit IU of a bidirectional BN, the IU consequently forwarding the authentication request to the MBN authentication centre MAC. The mobile node is able to initiate a binding update procedure for registering its own location information with its home agent HA and the correspondent node CN.

The mobile node is also able to edit its mapping from IP Quality of Service (QoS) to MBN Traffic Class (MBN_TC, see Figure 4). An example of a

QoS-to-MBN traffic class mapping is as follows. When users enter or update their subscriptions, they can select their QoS and MBN_TC mappings. The MBN operator can provide several mapping tables, each of which corresponds to a different price or tariff. The user selects one mapping table. Later on, the user may modify the mapping table (by calling the operator), access and modify its profile (eg via a web/wap browser or by using special software). Once the mapping is changed, the charging method will be changed accordingly. The traffic controller TPC uses such mappings as a basis for determining the specific xx_IU unit via which a given kind of traffic is conveyed.

Figure 2 illustrates a general addressing concept within the MBN. IPv6 employs two types of care-of addresses (COA): a primary COA and a co-located COA. Because of the addressing structure of IPv6, there is usually no need to have separate foreign agents for mobility support (in contrast to IPv4), and the COAs are co-located COAs. A mobile node may have multiple COAs, and a single home agent may store more than one COA for one mobile node. But at any one time, only one COA is registered as the primary COA to which the home agent tunnels MN-terminated data.

The home agent HA knows the care-of address associated with the traffic controller TPC. Preferably, the mobile node's primary COA is the subnetwork prefix of the TPC plus the MN's MIN. An advantage of this addressing scheme is that the TPC is able to see the MN's address and route the data to its final destination even if the HA encrypts MN-terminated tunnelled data.

According to a preferred feature of the invention, the primary COA registered in the home agent is associated with the traffic policy controller TPC. In other words, the COA's prefix is the TPC's subnetwork prefix and the last part is the mobile node's own MIN. The TPC acts as a router for the traffic heading toward the COA. The COA stored in the CN is associated with the relevant interface unit IU. This address allocation trick forces the traffic to be routed via the TPC during the start of a session, and allows traffic routing directly via the selected IU during the remainder of the session. The MN and the CN may open a second session in parallel to the first session. The data packets of the parallel session may be routed directly to the MN via the IU if no resource reservation is needed.

In the example shown in Figure 2, the home agent HA maintains the primary COA 202 of the mobile node MN. The primary COA 202 is the IP address 202 of the traffic controller TPC used by MN. Optionally, the HA may

also store the IP address 204 of the MN within the subnetwork under the downlink interface unit currently used by the MN. In this example, there are two possible downlink interface units x_IU and y_IU, of which y_IU is selected. The traffic controller TPC maintains the IP address 208 of the downlink interface unit y_IU currently used by the MN and the IP address 206 of another downlink interface unit x_IU. The downlink interface units in turn maintain the mobile node's COA (210 and 212) in each respective subnetwork.

During the start of a session, the first packet is routed by using the addresses 202, 208 and 212. As soon as the correspondent node CN registers the MN's new mobility binding, subsequent packets are routed by using the mobile node's COA 214 within the subnetwork defined by the downlink interface unit y_IU.

Figure 3 shows an example of a traffic handling policy table THPT. For each MBN Traffic Class (MBN_TC), the THPT defines the traffic handling policy to be applied. The THPT can be similar or different between different MBN networks. Column ST indicates the service type of the traffic class. In this context, "service type" is a generic term and not a name of a field in an IPv4 packet header. The possible values are "best effort" (BE) and "guaranteed service" (GS). (In a radio network, however, "guaranteed" must be read as "guaranteed if possible"). BW means bandwidth (measured by some appropriate and sufficient metrics), and IMP means importance. Low-importance data packets are discarded first if sufficient bandwidth is not available. The column marked "other" can be used for example to implement policies with time dependant validity. This means that daytime priorities can be different from night-time priorities.

Figure 4 shows an example of a mapping table QMTC for mapping QoS in a data packet's IP header into a traffic class within the MBN (QMTC = QoS to MBN_TPC). This table is subscriber-specific and maps IPv6 traffic classes IP_TPC into MBN traffic classes MBN_TPC. The traffic class in question is indicated by the packet's header.

Figure 5 shows an example of a list ACAL of the mobile node's available care-of address (ACAL = Available Care-of Address List). For each mobile node, there is a corresponding ACAL table which lists, in decreasing order of preference, alternative available care-of addresses in each available downlink bearer, cell or channel. In the example shown in Figure 5, there are two available care-of addresses for DVB (downlink) and one for GPRS

(uplink). SPx is the subnetwork prefix of subnetwork x, and MIN is the MBN interface number for the mobile node. The mobile node continuously measures signal strength (or some other signal quality parameter, such as the bit error ratio) of each available broadcast channel. It sends the measurement results to the mobility management unit MMU, which maintains a list of channels having an acceptable signal quality. Then the MMU translates this list into a list of care-of addresses wherein each channel corresponds to a combination of the relevant subnetwork prefix and the mobile node's care-of address. Then the MMU arranges the ACAL list according to preference (signal quality) and sends the ACAL list to the traffic controller TPC. It is the traffic controller's responsibility to make the final decision concerning the care-of address to be used. Three example situations illustrate the decision-making process.

In a first situation, the mobile node is powered on but does not receive data from any CN. When the first packet arrives from a CN, the packet is tunnelled by the HA to the MN's COA associated with the TPC. The TPC, acting as a default router, receives the packet and makes the cell/channel decision on the basis of the ACAL list. After making the decision, it pages the MN, builds a routing path to the MN via the selected IU, and routes the packet via the IU to the MN. The TPC also informs the MMU about the decision so that the MMU can monitor the signal quality (strength) of the active cell and make appropriate handover decisions.

In a second situation, there is an ongoing session and the mobile node is moving from one place to another. This move requires the ACAL list to be changed. The MMU updates the ACAL list. If the MMU determines that a handover is necessary, it sends the TPC a request to select a new cell on the basis of the new ACAL. In this case too, the TPC informs the MMU about the decision, and the MMU assists the MN to complete the handover.

In a third situation, a resource changes. Accordingly, the MN may have to be handed over to another cell/channel. In this case, the TPC makes the decision on the basis of the ACAL and instructs the MMU to perform the rest of the handover.

Figure 6 is a signalling diagram illustrating registration and resource reservation. Each MBN has a traffic handling policy table THPT (see Figure 3). In step RR0, the MN wants to initiate a registration process. The MN is assumed to have some rights in one uplink network, which in this example is the GPRS network. The MN has no rights yet in the broadcast networks, but it

monitors the broadcast links to obtain the identifier or IP address of the traffic controller TPC which controls the area in question. In step RR2, the MN sends the authentication centre MAC an authentication request comprising the MN's MIN (MBN interface number) and the IP address of the TPC (obtained in the previous step). In step RR4, the MN is authenticated by the authentication centre MAC. The authentication process is the topic of a co-pending patent application filed on the same day as the present application. For the purposes of the present invention, it will suffice to say that after the authentication process, the MAC knows whether the MN is allowed to access this MBN. If the authentication is completed successfully, in step RR6 the MAC consults the home registration unit HRU to get the MN's Access Permission List APL, which indicates the MN's rights in each BN. The HRU of a visiting MN may be located in a different MBN. The TPC also negotiates with the HRU to obtain the subscriber's preferences, such as the QMTC table shown in Figure 4. In step RR7, the MAC decides whether the TPC is appropriate, considering the APL list. In step RR8, the MAC informs the TPC that the authentication was successful, and reports the subscriber preference information. In step RR10, the MN receives an indication that the authentication was completed successfully. Also, the MAC establishes a security association between the MN and the SSN (the TPC, MMU and RCU). For example, a session key may be distributed to the MN and the SSN. The session key allows encrypted communication between the MN and the SSN. In a registration step RR11, the MN sends its address in the uplink and downlink bearer networks to the TPC. In step RR12, the MN reports the following information to the TPC, which passes it on to the MMU (which preferably shares the TPC's IP address): 1) signal quality of each available cell/channel in the broadcast network(s), and 2) available bidirectional bearers. In step RR14, the TPC/MMU selects the acceptable cell(s)/channel(s) in the broadcast network(s) and prepares the ACAL list (Available Care-of Address List, see Figure 5). In step RR16, the MMU gives the ACAL list to the TPC. In step RR20, the MN initiates a registration with its home agent HA by sending a mobility binding COA(MN) = COA(TPC-MN). In other words, the MN's COA within the HA is the COA associated with the TPC. In steps RR22 and RR24, the HA updates and acknowledges the MN's mobility binding. Any correspondent node CN may now reach the MN via its HA by sending a packet with the IP address of the MN.

Figure 7 is a signalling diagram illustrating the start of a session. The set of events begins in step SS2 in which the MN's correspondent node CN knows the MN's IP address IP(MN). In step SS4, the CN does not know the mobility binding in the HA. Thus the first user data packet is routed to the HA. (In Figure 7, 'data' refers to data packets of session 1, and 'data 2' refers to data packets of session 2.) In step SS6, because the HA stores the TPC's IP address as the MN's primary COA, the packet is tunnelled to the TPC. In step SS8, the TPC uses the QMTC table to classify the incoming packet to its MBN traffic class. Next, the TPC uses the ACAL table (which combines the subscriber's preference, the MBN operator's traffic policies, and available traffic/resource information (resource availability data) obtained from the RCU) to select a downlink bearer.

Steps SS10 to SS16 relate to resource reservation, which the TPC performs only when necessary (for guaranteed service). Resource reservation is specific to the data flow. For example, if the data flow in question belongs to MBN traffic class 5, the TPC reserves a certain amount of bandwidth in the selected cell (under the COA indicated by the ACAL). In step SS10, the RCU preferably maintains a database (eg a fast look-up table) that indicates resource availability in all cells under the TPC, and in the neighbouring cells (for smooth handover). If the incoming traffic belongs to best effort service, the TPC selects the cell only on the basis of the resource availability table. If the incoming traffic belongs to guaranteed service, the TPC checks 1) if resource reservation has been performed, and 2) if not, how much bandwidth has to be reserved (based on the QMTC and THPT tables). By looking at the resource availability table, the TPC determines a suitable channel, but it requests the RCU to perform the actual channel reservation. In step SS12, the RCU makes a decision about resource reservation and sends the decision to the downlink interface unit DL_IU (in this example: a DVB interface unit). Steps SS14 and SS16 are the corresponding acknowledgements.

Steps SS18 and SS20 relate to paging the mobile node MN. If the MN is not active in the selected bearer or channel, it needs to be paged. In step SS18, the MN is paged via the uplink interface unit UL_IU (a GPRS interface unit in this example). Step SS20 is the paging response from the MN.

In step SS22, the first user data packet to the MN is forwarded to the downlink interface unit DL_IU. In step SS24, the DL_IU checks that the recipient's COA is authorized and the resource reservation is valid. In step

SS26, the DL_IU forwards the first user data packet to the MN. In step SS28, the MN notices the incoming data packet from the CN and responds with a mobility binding of COA(MN) = COA(IU-MN). In other words, the COA is associated with the DL_IU. The subnetwork prefix is the same as with the DL_IU, and the second part of the address is the MIN. In step SS30, the CN updates the MN's mobility binding. In step SS32, the CN begins to send MN-terminated data packets directly to the DL_IU, thus bypassing the intervening elements (the HRU, the HA and the TPC). In reality, the CN may have sent more than one packet before receiving the MN's updated mobility binding in step SS28, in which case the TPC may have to route more than one packet to the MN.

In step SS34, if the same CN needs to open another session for the MN, and the new session requires best effort service (no resource reservation needed), the data of the new session is sent just like the data in step SS32 (the final step being shown by a dotted arrow). But if the new session requires guaranteed service (which in turn requires resource reservation), the first packet of the new session is routed from the DL_IU to the TPC, as shown in step SS36. In step SS38, the TPC performs resource reservation for the second session. This step comprises the detailed steps of SS10 to SS16. In step SS40, the first data packet of the second session is routed to the MN. In step SS42, subsequent packets of the second session are routed to the MN.

No explicit messages to end a session are needed. If there are no MN-terminated packets for a predefined time, the IU can simply delete the information related to the MN from its cache and inform the TPC about its action. The MN may maintain a similar timer. If it receives no packets before the timer expires, the MN stops monitoring the broadcast bearer for user data. If the MN is still expecting data when the timer is about to expire, the MN may request the IU to temporarily extend the time limit. The IU may accept or reject the request.

In order to save the battery of a portable mobile node, it is preferable that the mobile node only monitors one bearer type (network) at a time. For example, the subscriber data related to the mobile node can include a default bearer type, such as GSM or UMTS. The mobile node should be paged on this bearer. The mobile node can be ordered to monitor the selected bearer type by sending a modified page message which indicates the selected bearer type, channel, possible decryption data, etc. Alternatively, such information can be sent in a separate message, such as a data call or the like.

DxB microcell architecture

Figure 8 illustrates a cellular broadcast network. The cellular broadcast network concept has been introduced for data broadcasting in DxB networks. The concept introduces DxB microcells. In some areas, such as department stores, supermarkets and the like, a DxB network may comprise two overlapping cell structures. Such areas are covered by normal DxB cells 81, called macrocells, and by smaller cells 82 to 85, called microcells. The microcells provide content which is customized according to a particular site. To optimize network architecture for such a microcell site, a preferred embodiment of the invention introduces two new elements, namely an aggregate interface unit AIU and a broadcast router BR. Each broadcast router BR is coupled to a single microcell transmitter. It encapsulates IP data into protocols suitable for a DxB bearer. Several broadcast routers are connected to the MBN backbone via a single aggregate interface unit AIU. The AIU acts not only as a router for the BRs, but also as a centralized resource management unit. Employing the AIU and BR elements reduces key management load and signalling related to resource management.

Figure 9 illustrates packet routing and the various data structures in a system as shown in Figure 8. The aggregate interface unit AIU comprises a channel allocation table CAT having a resource entry for each combination of a broadcast router BR and channel. The CAT table may indicate usage of the resources by some appropriate metric. The channel identifiers Ch1 to Chn may represent physical channels, such as several 8MHz channels in a DVB-T network. Each broadcast router BR1 to BRn comprises a channel mapping table CMT1, CMT2, etc. The channel mapping tables map the mobile node's care-of address COA to a channel identifier. Reference signs 91 to 9n denote the microcells under one AIU. x and y are two indices within the range of 1 to n. The mobile node MN in cell 9y. Reference sign 95 denotes a data packet arriving to the AIU. The data packet's header indicates the COA as COA(BRx_MN), which means the BRx subnetwork prefix plus the mobile node's MIN. The AIU's own IP address IP(AIU) is only used when the AIU needs to receive signalling packets from other units, such as the TPC, but this address is not used for routing data to the MN. The AIU uses the CAT table to convert the data packet 95 to a data packet 96 whose header indicates the COA of BRy, under which the MN is located. BRy uses its channel mapping table CMT to convert the data packet 96 to a data packet 97, which is an IP

packet encapsulated in a DxB packet. In other words, the data packet 97 has a DxB header in addition to the IP header.

Acronyms (some are not official):

ACAL: Available Care-of Address List
AIU: Aggregate Interface Unit
APL: Access Permission List
BB: Backbone Network
BG: Border Gateway
BN: Bearer Network
BR: Broadcast Router
CN: Correspondent Node
CAT/CMT: Channel Allocation/Mapping Table
COA: Care-Of Addresses
DL: Downlink
DxB: DAB or DVB
FW: Firewall
HA: Home Agent
HAN: Home Administration Node(s)
HRU: Home Register Unit
IP: Internet Protocol
IU: Interface Units
MAC: MBN Authentication Centre
MB: Mobility Binding
MBN: Multi-Bearer Network
MBN_TC: MBN Traffic Class
MHA: MBN Home Agent
MIN: MBN Interface Number
MMU: Mobility Management Unit
MN: Mobile Node
PDP: Packet Data Protocol
QMTC: QoS to MBN_TPC
QoS: Quality of Service
RMU: Resource Management Unit
SSN: Service Support Nodes
THPT: Traffic Handling Policy Table
TPC: Traffic Policy Controller

UL: Uplink

Reference:

1. MEMO network documentation (collectively referred to as the "MEMO concept"), available at `http://memo.lboro.ac.uk`

Claims

1. A method for routing data packets (DP) to a mobile node (MN) from its correspondent node (CN), via a multi-bearer network, or MBN, the MBN comprising at least one uplink bearer network (GSM, GPRS, UMTS) and at least one downlink bearer network (DxB), the backbone network comprising gateway means (BG/FW) to an IP network (IPN);

characterized by

receiving and maintaining resource availability information (RR12) concerning the at least one downlink bearer network (DxB);

receiving and maintaining subscriber preference information (QMTC) concerning the mobile node;

maintaining traffic policy information (THPT) concerning the MBN;

in a centralized traffic policy controller (TPC), combining the subscriber preference information (QMTC), the traffic policy information (THPT) and the resource availability data (RR12) into a routing table (ACAL) and using the routing table (ACAL) for routing (SS26) one or a few initial data packets of a new session from the correspondent node (CN) to the mobile node (MN);

performing a binding update between the mobile node (MN) and the correspondent node (CN) such that subsequent data packets of an ongoing session bypass the traffic policy controller.

2. A method for routing data packets (DP) to a mobile node (MN) from its correspondent node (CN), via a multi-bearer network, or MBN, the MBN comprising at least one uplink bearer network (GSM, GPRS, UMTS) and at least one downlink bearer network (DxB), the backbone network comprising gateway means (BG/FW) to an IP network (IPN);

characterized by

storing an address (202) associated with a centralized traffic policy controller (TPC) as the mobile node's care-of address in its home agent (HA);

routing (SS4, SS6) an initial data packet via the home agent and the centralized traffic policy controller to a bearer network interface unit (DL_IU) serving the mobile node;

in response to said routing, storing an address (214) of the bearer network interface unit as the mobile node's care-of address in the correspondent node (CN);

in response to said updating, routing (SS32, SS34, SS42) subsequent data packets from the correspondent node (CN) to the bearer network

interface unit (DL_IU), whereby the home agent (HA) and the centralized traffic policy controller are bypassed.

3. A method according to claim 2, characterized in that routing the initial data packet comprises the steps of:

determining whether the data packet's header indicates guaranteed service; and if yes:

reserving the necessary resources in the downlink bearer network (DxB).

4. A backbone network (BB) for a multi-bearer network, or MBN, to route data packets (DP) to a mobile node (MN) from its correspondent node (CN), the MBN comprising at least one uplink bearer network (GSM, GPRS, UMTS) and at least one downlink bearer network (DxB), the backbone network comprising gateway means (BG/FW) to an IP network (IPN);

wherein the MBN comprises or is operationally coupled to a home agent function (HA, HAN);

characterized by

an access control node set (MAC) for centralized granting or rejecting the mobile node's (MN) rights to services via the backbone network (BB) and for storing subscriber preference information (QMTC) related to the mobile node;

a service support node set (SSN) for:

- centralized administration and distribution of traffic policies (THPT);

- centralized mobility management for managing the mobility of the mobile node within each downlink bearer network (DxB);

- centralized resource control for making resource reservation decisions within each downlink bearer network (DxB); and

an interface unit set (IU) for interfacing to and for carrying out the resource reservation decisions in the at least one downlink bearer network (DxB).

5. A service support node set (SSN) for a backbone network (BB) of a multi-bearer network, or MBN, to route data packets (DP) to a mobile node (MN) from its correspondent node (CN), the MBN comprising at least one uplink bearer network (GSM, GPRS, UMTS) and at least one cellular downlink

bearer network (DxB), the backbone network comprising gateway means (BG/FW) to an IP network (IPN) and at least one downlink interface unit (DxB_IU) toward each downlink bearer network (DxB);

characterized by

means for receiving subscriber preference information (QMTC) related to the mobile node;

a mobility management unit (MMU) for centralized mobility management of the mobile node within the at least one downlink bearer network (DxB);

means (TPC, RCU, MMU) for maintaining resource availability data (RR12) and making resource reservation commands (SS12) concerning said at least one downlink bearer network (DxB);

means (TPC) for combining traffic policy information (THPT), said subscriber preference information (QMTC) and said resource availability data (RR12) into a routing table (ACAL), and for routing one or a few initial data packets of a new session on the basis of said routing table; and

means for transmitting resource reservation decisions (SS12) to the at least one downlink interface unit (DxB_IU).

6. A service support node set (SSN) according to claim 5, characterized in that the routing table (ACAL) maps at least one IP address to a cell/channel combination within the at least one downlink bearer network (DxB).

7. An interface unit set (DxB_IU) for interfacing a backbone network (BB) of a multi-bearer network to a downlink bearer network (DxB), to route data packets (DP) to a mobile node (MN) within the downlink bearer network;

characterized by:

means for conveying an initial access request (RR2) from the mobile node (MN) to an access control node set (MAC), the access control node set controlling access to services within and via the backbone network (BB);

resource monitoring means (RMU) for receiving and carrying out resource reservation decisions (SS12) concerning the downlink bearer network (DxB);

interface means (DxB_IU) for routing data packets to a mobile node (MN) according to said mobile-node-specific traffic policies (QMTC);

a resource management unit (RMU) closely coupled to the interface unit (DxB_IU), for carrying out resource reservation decisions (SS12).

8. An interface unit set (DxB_IU) according to claim 7, characterized in that each interface unit defines an Internet protocol subnetwork comprising all cells under the interface unit in question.

9. An interface unit set (DxB_IU, AIU, BR) according to claim 7 or 8, characterized by means (AIU, BR) for supporting multiple geographically overlapping cell structures (81; 82 - 85) in a DAB and/or DVB network.

10. A mobile node (MN) characterized by

radio interface means to multiple different bearer networks (BN), at least one bearer network being a broadcast network;

registration means for registering with a backbone network (BB, MAC) controlling said multiple different bearer networks; and

mobility binding update means, responsive to said registration means, for updating the mobile node's mobility binding via the backbone network.

Fig. 1

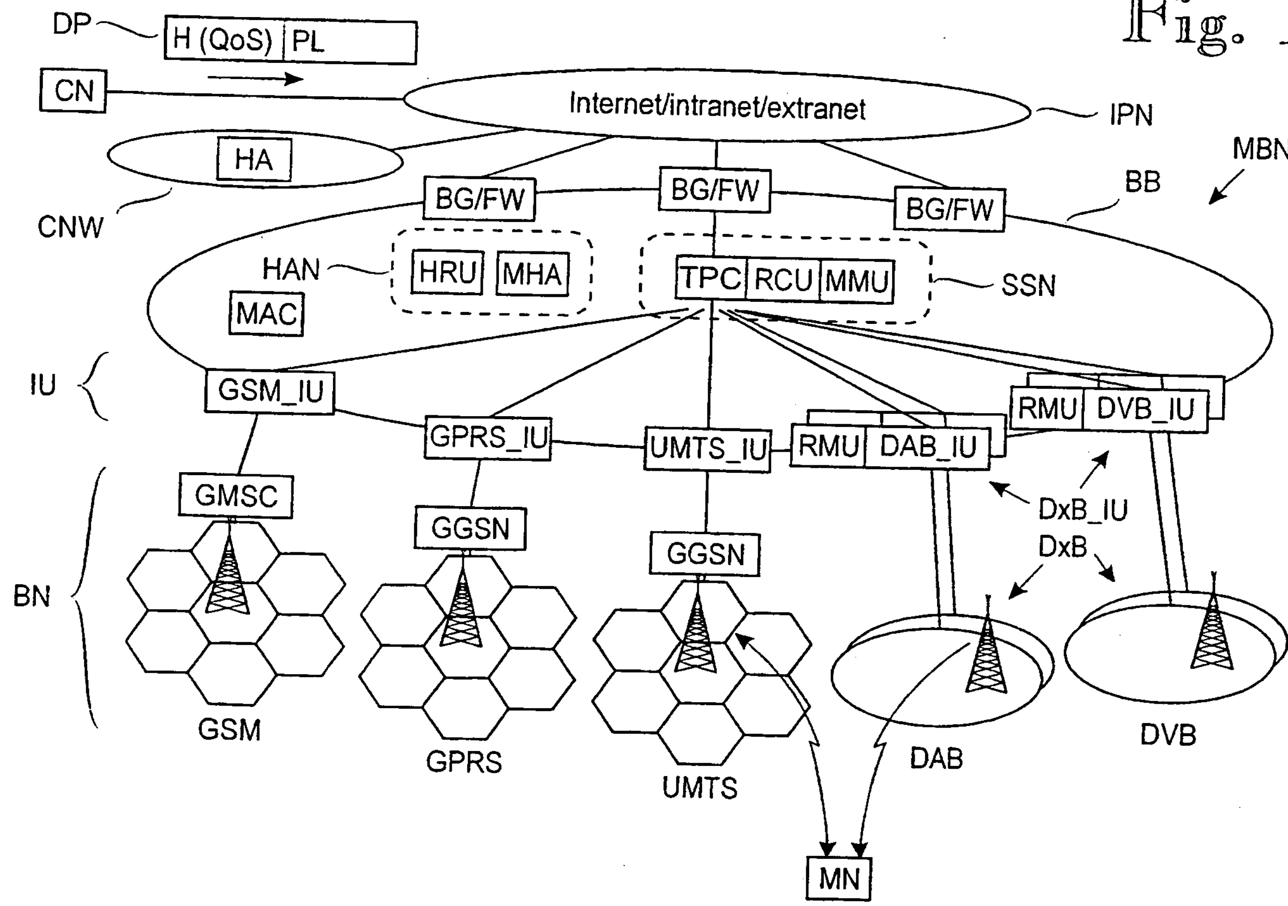

DP
H (QoS)
PL
CN
Internet/intranet/extranet
IPN
HA
CNW
BG/FW
BG/FW
BG/FW
BB
MBN
HAN
HRU
MHA
MAC
TPC
RCU
MMU
SSN
IU
GSM_IU
GPRS_IU
UMTS_IU
RMU
DAB_IU
RMU
DVB_IU
DxB_IU
DxB
GMSC
GGSN
GGSN
BN
GSM
GPRS
UMTS
DAB
DVB
MN

Fig. 2

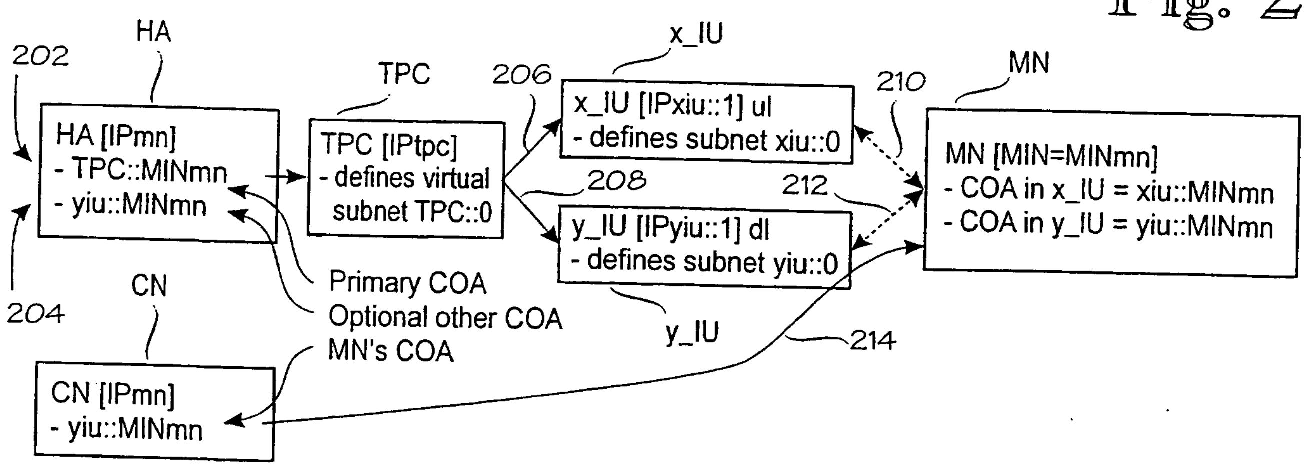

HA
202
HA [IPmn]
- TPC::MINmn
- yiu::MINmn
204
TPC
TPC [IPtpc]
- defines virtual
subnet TPC::0
206
x_IU
x_IU [IPxiu::1] ul
- defines subnet xiu::0
208
y_IU [IPyiu::1] dl
- defines subnet yiu::0
y_IU
210
212
214
MN
MN [MIN=MINmn]
- COA in x_IU = xiu::MINmn
- COA in y_IU = yiu::MINmn
Primary COA
Optional other COA
MN's COA
CN
CN [IPmn]
- yiu::MINmn

Fig. 3

THPT

	Policy to be applied		
MBN_Tc	ST	BW/IMP	Other
1	BE	IMP=1	
2	BE	IMP=2	
3	BE	IMP=3	
4	GS	BW=xx	
5	GS	BW=yy	
6	GS	BW=zz	
...			

Fig. 4

QMTC

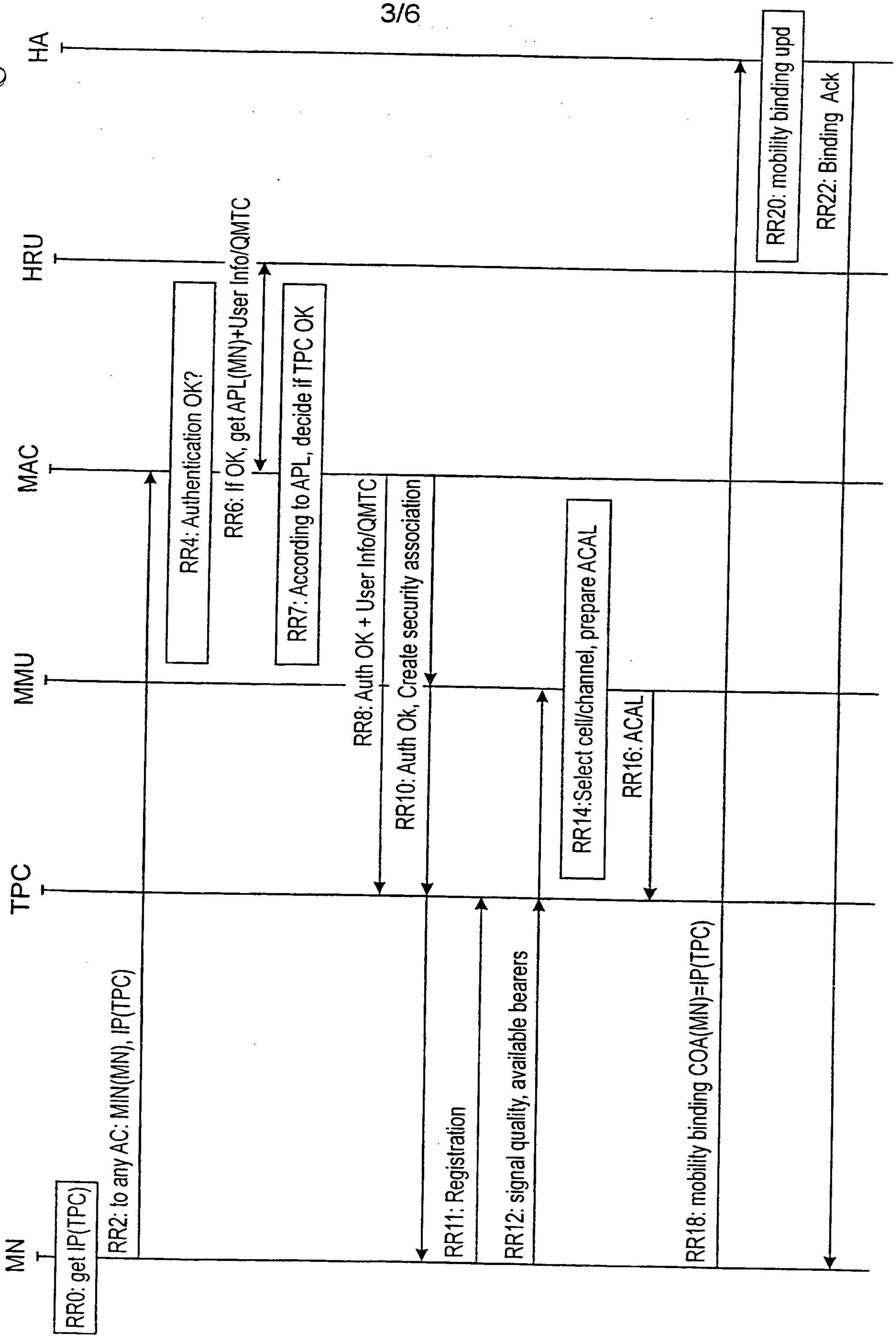
IP_TC	MBN_TC
1 - 2	1
3 - 4	2
5 - 7	3
8	4
...	

Fig. 5

ACAL

	Available COAs according to preference level				
BN	1		2		3
DAB	-	-	-		
	-	-	-	-	-
DVB	IUx::MIN		IUy::MIN		-
	Cell_ID:IUy	Channel_ID: u	Cell_ID:IUy	Channel_ID: w	
UMTS	-		-		-
GPRS	IUa::MIN		-		-
GSM	-		-		-

Fig. 6


MN
TPC
MMU
MAC
HRU
HA
RR0: get IP(TPC)
RR2: to any AC: MIN(MN), IP(TPC)
RR4: Authentication OK?
RR6: If OK, get APL(MN)+User Info/QMTC
RR7: According to APL, decide if TPC OK
RR8: Auth OK + User Info/QMTC
RR10: Auth Ok, Create security association
RR11: Registration
RR12: signal quality, available bearers
RR14:Select cell/channel, prepare ACAL
RR16: ACAL
RR18: mobility binding COA(MN)=IP(TPC)
RR20: mobility binding upd
RR22: Binding Ack

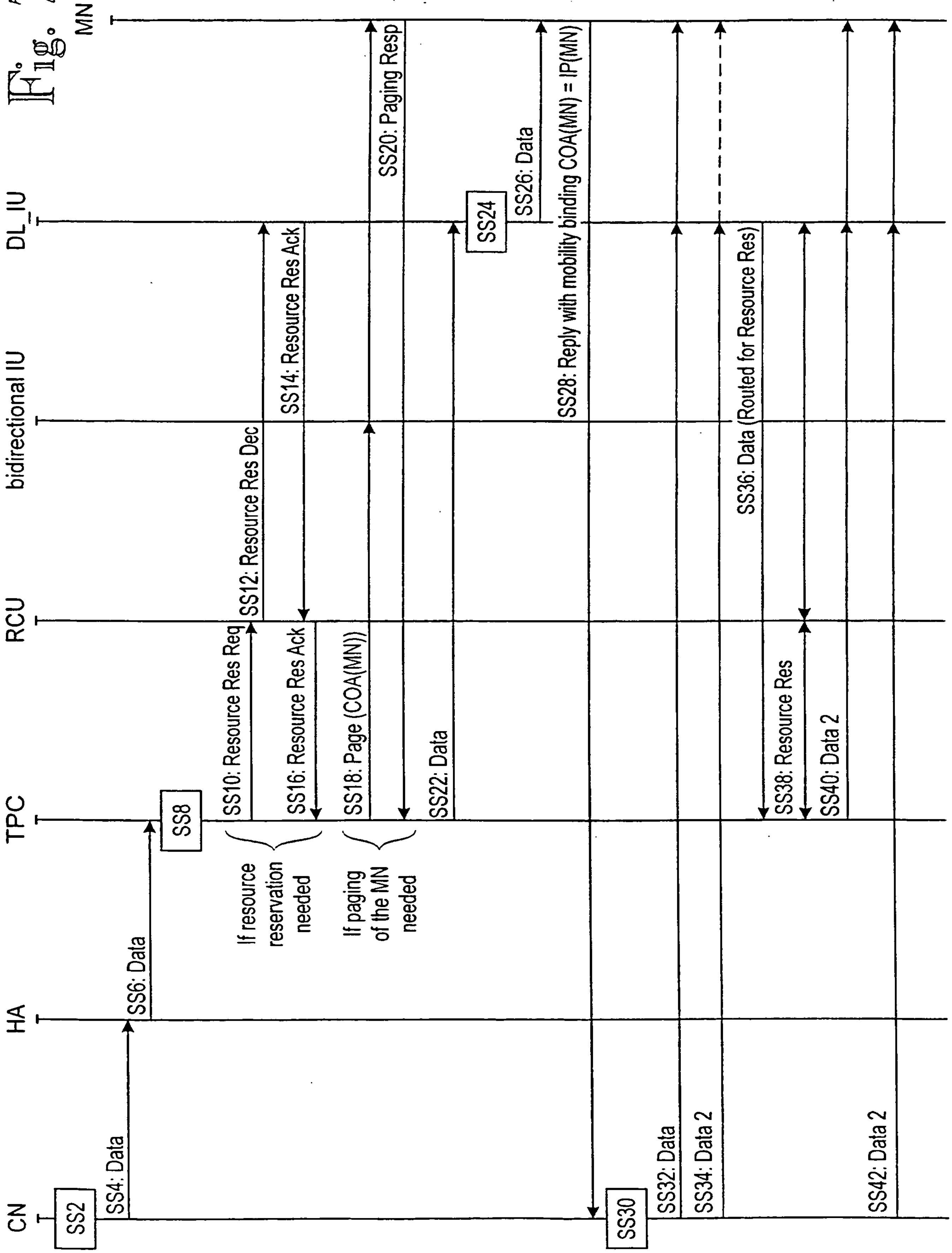

CN
HA
TPC
RCU
bidirectional IU
DL_IU
MN
SS2
SS4: Data
SS6: Data
SS8
SS10: Resource Res Req
SS12: Resource Res Dec
SS14: Resource Res Ack
SS16: Resource Res Ack
If resource reservation needed
SS18: Page (COA(MN))
SS20: Paging Resp
If paging of the MN needed
SS22: Data
SS24
SS26: Data
SS28: Reply with mobility binding COA(MN) = IP(MN)
SS30
SS32: Data
SS34: Data 2
SS36: Data (Routed for Resource Res)
SS38: Resource Res
SS40: Data 2
SS42: Data 2

Fig. 7

Fig. 8

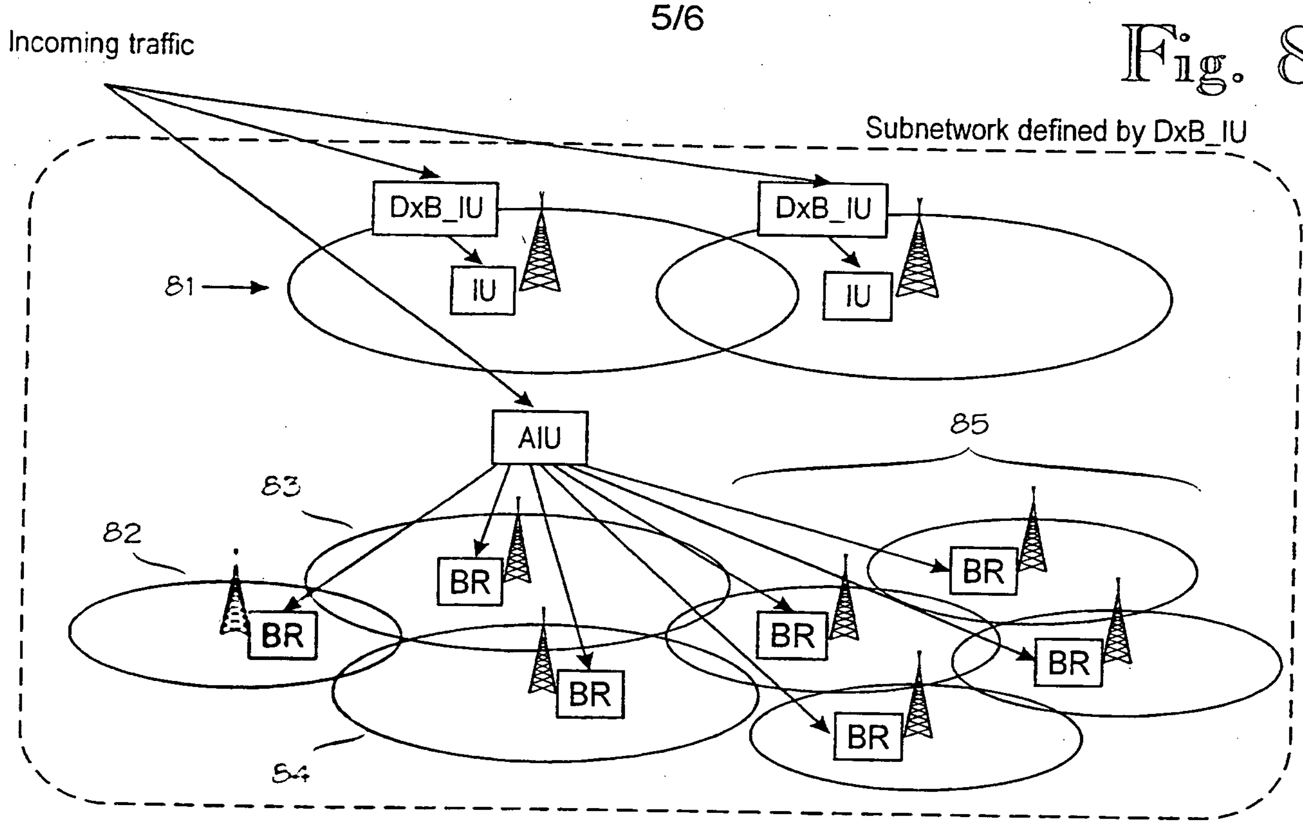
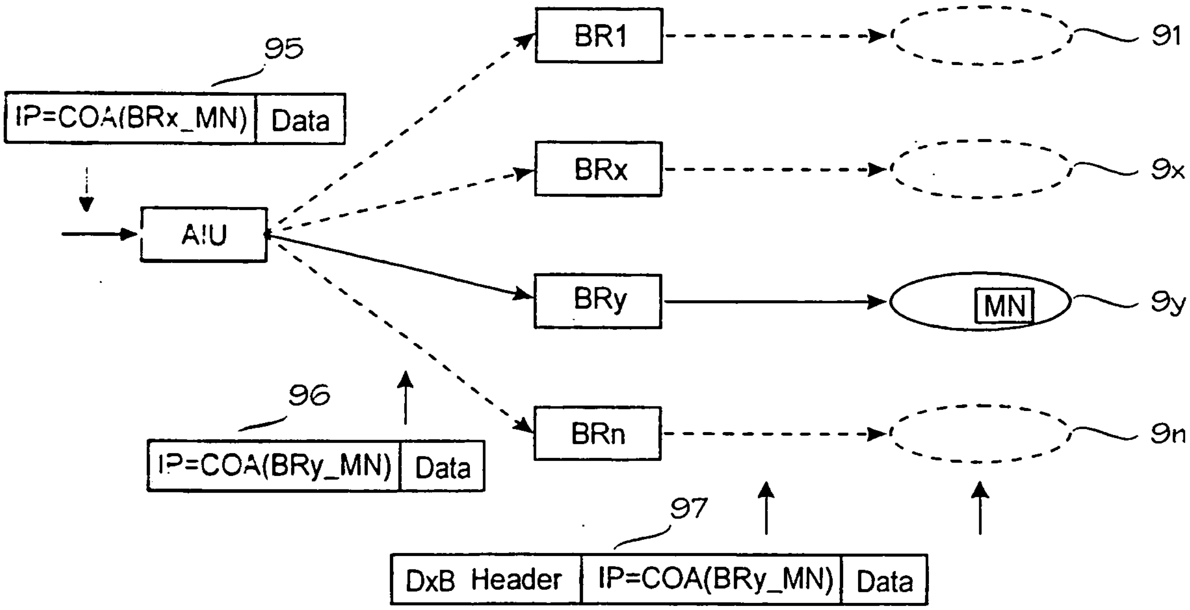

Incoming traffic
Subnetwork defined by DxB_IU
DxB_IU
DxB_IU
IU
IU
81
AIU
85
83
82
BR
BR
BR
BR
BR
BR
BR
54

Fig. 9



CAT

BR	Ch1	Ch2	...	Chn
BR1	xx	xx	...	xx
BR2	xx	xx	...	xx
BR3	xx	xx	...	xx
BR4	xx	xx	...	xx

CMT1

COA	Ch-id
IP(BR1)::2	1
IP(BR1)::3	2
IP(BR1)::4	–
IP(BR1)::5	2
...	...
IP(BR1)::n	3

CMT2

COA	Ch-id
IP(BR2)::2	1
IP(BR2)::3	2
IP(BR2)::4	–
IP(BR2)::5	2
...	...
IP(BR2)::n	3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 01/00306

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04Q 7/22, H04Q 7/38
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04Q, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 9931846 A1 (BRITISH TELECOMMUNICATIONS PUBLIC LIMITED COMPANY), 24 June 1999 (24.06.99), page 5, line 13 - line 26; page 7, line 24 - page 9, line 12; page 10, line 4 - page 12, line 26, page 13, line 7 - line 23; figure 3	1,2,10
A		3-9
	--	
Y	WO 9931853 A1 (BRITISH TELECOMMUNICATIONS PUBLIC LIMITED SOMPANY), 24 June 1999 (24.06.99), page 6, line 1 - page 7, line 18; page 8, line 22 - page 11, line 2; page 12, line 7 - line 17, figure 3a	1,2,10
A		3-9
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 July 2001	20-07-2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Elisabet Åselius / MRo Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 01/00306

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	1999 IEEE International Conference on Communications (Cat. No. 99CH36311), 1999 International Conference on Communications, Vancouver, BC, Canada, 6-10 June 1999, (CHIRUVOLU G ET AL), "Mobility and QoS support for IPv6-based real-time wireless Internet traffic", 334 - 338 vol. 1, see the whole document --	1-10
P,A	WO 0045560 A2 (TELEFONAKTIEBOLAGET LM ERICSSON), 3 August 2000 (03.08.00), page 9, line 4 - page 10, line 2; page 19, line 8 - page 21, line 8 --	1-10
P,A	EP 1047244 A1 (LUCENT TECHNOLOGIES INC.), 25 October 2000 (25.10.00), column 2, line 44 - column 4, line 5 -- --------	1-10

INTERNATIONAL SEARCH REPORT
Information on patent family members

02/07/01

International application No.
PCT/FI 01/00306

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9931846 A1	24/06/99	AU 1498399 A	05/07/99
		CN 1282476 T	31/01/01
		EP 1040622 A	04/10/00
		GB 9726647 D	00/00/00
WO 9931853 A1	24/06/99	AU 1498099 A	05/07/99
		CN 1282481 T	31/01/01
		EP 1053620 A	22/11/00
		GB 9726643 D	00/00/00
WO 0045560 A2	03/08/00	AU 2704500 A	18/08/00
EP 1047244 A1	25/10/00	AU 2930300 A	02/11/00
		WO 0064121 A	26/10/00